21.16A

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Safe Handling of Chemical Carcinogens in Research Laboratories

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Contents

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1. Introduction

This supplement covers regulations and procedures that must be used when working with chemical carcinogens in research laboratories. See Supplement 21.16B for policy on work with carcinogens in all other workplaces.

Of over 450 materials identified by various organizations as chemical carcinogens, most do not have workplace safety regulations. Furthermore, the Occupational Safety and Health Administration (OSHA) standards for carcinogens used in research laboratories differ from those used in other workplaces (hereinafter referred to as nonlaboratories). These substances include materials with varying carcinogenic potency, some of which produce adverse effects more rapidly and easily than others. In addition, workplace exposure patterns and circumstances differ from exposures to substances intended to be drugs, food additives, or pesticides. Therefore, the relevance of animal tests and other data indicating a carcinogenic potential must be critically reviewed for their appropriateness for the occupational setting.

LLNL's requirements for carcinogen use are based on OSHA regulations and DOE orders, specifically 5480.8A (Contractor Occupational Medical Program) and 5480.10 (Contractor Industrial Hygiene Program). Figure 1 shows an overview of the workplace requirements for carcinogens. See Appendix A for the terms and definitions used in this supplement.

1.1 Purpose and Scope

This supplement

- Summarizes various environmental, safety, and health requirements for work involving the use of chemicals that are human or human-suspect carcinogens in research laboratories. Supplement 21.16B covers the use of carcinogens in all other workplaces.
- Establishes safety controls for the use of chemical carcinogens based on the potency of materials and the conditions found in a particular operation. Each material and its usage shall be evaluated individually, and a hazard evaluation for each situation shall be completed to determine the appropriate handling procedures.
- Presents LLNL's approach to minimizing exposure to levels as low as reasonably achievable.
- Provides a framework for evaluating hazards and for selecting the appropriate control measures in cases where there are no mandatory requirements.

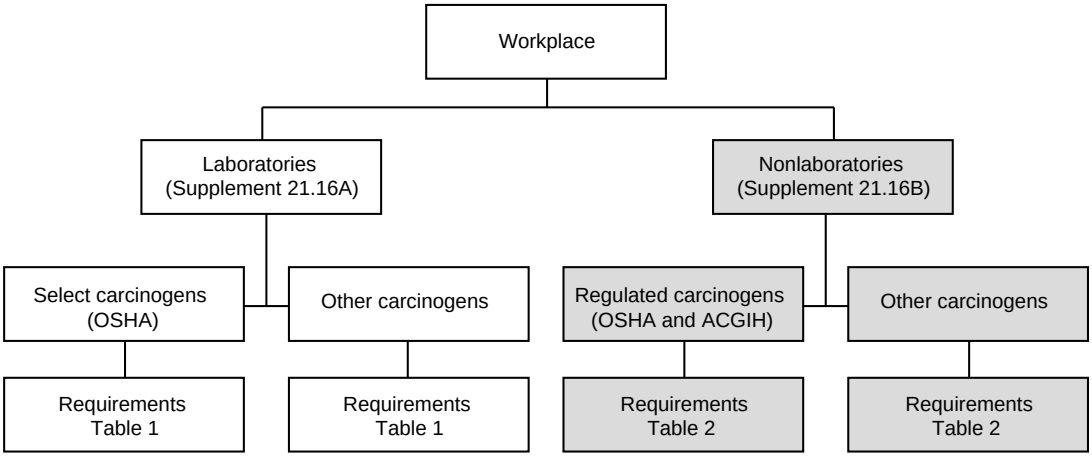


Figure 1. Workplace requirements for carcinogens (shaded boxes applicable to Supplement 21.16B only).

The evaluation and handling approaches covered in this supplement apply to the control of exposure to carcinogens; however, they can also be applied to other materials (e.g., mutagens or teratogens) with high toxicity. For further details on minimizing exposure to these agents, consult with the industrial hygienist for your area environment, safety, and health (ES&H) team.

Requirements for beryllium and asbestos are covered in Supplements 21.10 and 21.19, respectively.

1.2 Applicability

The requirements in this supplement apply to research laboratories where chemical carcinogens are used or stored. For all other workplaces, see Supplement 21.16B.

1.2.1 Laboratories

For the purpose of OSHA regulations, laboratories are places where all of the following occur:

- Chemical manipulations are carried out on a laboratory scale.
- Multiple chemical procedures or chemicals are used.
- The procedures involved are neither part of a production process nor simulate one.
- Protective laboratory practices are commonly used, and equipment is available to minimize the potential for employee exposure to hazardous chemicals.

In chemical laboratories, the OSHA term *select carcinogens* is used for those carcinogens covered by the OSHA laboratory standard (29 CFR 1910.1450). The term *other carcinogens* applies to materials identified as having some cancer risk but have not been specifically regulated.

Laboratory workplaces will satisfy the carcinogen-use provisions of the OSHA laboratory standard if they comply with the requirements set forth in the section entitled "Use of Chemical Carcinogens in Laboratories." General laboratory safety requirements are described in Supplement 21.01, "Chemical Hygiene Plan for Laboratories," of the LLNL *Health & Safety Manual*.

1.2.2 Nonlaboratories

The requirements and procedures set forth in Supplement 21.16B will enable nonlaboratory workplaces to comply with regulations for OSHA carcinogens and with DOE Order 5480.10 for its listed carcinogens. DOE requires strict controls for materials beyond those listed by OSHA.

2. Use of Chemical Carcinogens in Laboratories

Chemical carcinogens may be used at LLNL only when no other practical substitutes are available. When such chemicals are used, employee exposure shall be kept at levels as low as reasonably achievable. Precautions for using these carcinogens safely in the research laboratory are determined by evaluating the hazards of the operation and applying controls. The following subsections describe the evaluation process and various control measures that shall be considered. Table 1 provides an overview of the requirements for using chemical carcinogens in laboratories.

2.1 Hazard Evaluation

2.1.1 Identification

To determine if a material is regulated because of its carcinogenic properties, refer to the "List of LLNL-Designated Carcinogens" developed by the Industrial Hygiene Group (ext. 2-1214) of Hazards Control. This list is updated as new toxicological information becomes available and is published separately from this supplement to simplify distribution. For help with identifying chemicals that are not on this list, contact the LLNL main and branch libraries or the industrial hygienist for your area ES&H team.

For the purposes of regulatory compliance in a laboratory, the two categories of carcinogens that have been identified are *select carcinogens*, which have more restrictive requirements, and *other carcinogens* (see Appendix A, Terms and Definitions).

The relative hazard of exposure to a chemical carcinogen depends not only on the type of carcinogen and its innate carcinogenic potency, but also on its physical and chemical properties, potential route(s) of exposure, duration of exposure, quantities handled, and the specific process

Table 1. Requirements for carcinogens in laboratories.

Requirement	Section	Select carcinogens[a]	Other carcinogens[b]
Hazard evaluation	**2.1**	√	+
Written safety procedure	**2.2.1**	+	+
Purchasing/receiving	**2.2.2**	+	**N/A**
Posting designated areas	**2.2.3**	√	**N/A**
Inventory	**2.2.4**	√	+
Labeling, packaging, and storing	**2.2.5**	√	√
Containment	**2.2.6**	√	√
Work practices	**2.2.7**	√	**N/A**
Monitoring	**2.2.8**	+	+
Waste disposal	**2.2.9**	√	√
Decontamination	**2.2.10**	√	√
Emergency plan	**2.2.11**	√	√
Employee training	**2.3**	√	√
Medical surveillance	**2.4**	+	**N/A**

[a] Applies to those compounds meeting the OSHA definition of *select carcinogens*.
[b] Applies to those compounds that are not OSHA *select carcinogens* but have been classified as carcinogens by other organizations.
√ = required in all cases.
+ = required in some cases.
N/A = not applicable.

involved. Therefore, the user, with assistance from the area industrial hygienist, shall examine these factors to classify carcinogen operations into safety control levels with varying degrees of requirements. Note that minimum requirements exist for all carcinogenic substances, and increasing safety levels are applied to those that are more hazardous. Appendix B includes the controls for the different safety levels.

2.1.2 Risk Assessment

Once the proposed use of a carcinogen has been identified, a risk assessment of the overall operation shall be performed to determine the appropriate safety requirements. Although some rules and controls are mandatory for carcinogens, the degree to which they are applied is based on assessing the risk and establishing safety control levels. Each level has specific controls to ensure personnel protection and to prevent environmental contamination. See Appendix B for instructions on how to determine the safety control levels for specific operations and for a summary of the requirements for each.

If an airborne carcinogen exceeds the prescribed OSHA or DOE action level (see Appendix A, Terms and Definition), certain procedures and surveillance must be implemented to reduce exposure. The ES&H team industrial hygienist shall provide guidance on a case-by-case basis for affected operations.

When appropriate, the area industrial hygienist and the environmental analyst will use the hazard review form (see Appendix C) or its equivalent (e.g., C&MS Project Work Plan) to evaluate the use and storage of *select carcinogens*. Each operation and the materials involved shall be evaluated and assigned controls as needed. Use of this form may determine the need for an operational safety procedure (OSP). For most cases, the initial review will be sufficient. However, if the process is too complex to be covered by a hazard review form, an OSP may be required. Formal, written hazard reviews are recommended but not required for *other carcinogens*.

2.2 Controls

2.2.1 Written Safety Procedures

An approved facility safety procedure (FSP) or OSP may be required based on the hazard reviews discussed in the section entitled "Risk Assessment." However, use of the hazard review form may be sufficient to ensure that all requirements are being implemented. If required, the OSP shall include

- Special controls that are not included in the controlling FSP.
- Monitoring procedures, where appropriate, for evidence of personnel exposure and/or environmental contamination.
- Methods for
  - — Decontaminating equipment and work surfaces.
  - — Handling carcinogenic wastes generated.
- Emergency procedures in the event of accidental spill and/or personnel exposure.

2.2.2 Purchasing/Receiving

When preparing a purchase requisition (Form LL-2350-2), check "toxic material" and add "carcinogen" in the key word section. When several items are being ordered, identify carcinogens as such, and order only the amount needed for the project. The Procurement Department will contact the Industrial Hygiene Group for approval of all purchase requisitions for carcinogens. NOTE: Unless approved by the area industrial hygienist, *select carcinogens* shall not be ordered through blanket purchase orders that bypass the LLNL purchasing system.

The Materials Management Section shall release carcinogenic materials from Central Supply stock only upon receiving an approved hazard review form or OSP. Some carcinogens available from Central Supply include benzene, chloroform, carbon tetrachloride, and formaldehyde.

Carcinogens shall be carefully handled and transferred on site to avoid accidental release or personnel exposure. Additional handling requirements that may be necessary for certain potent carcinogens include initial delivery to the Materials Management Section, inspection by a health and safety technician in a controlled environment, and storage in double containers in locked cabinets. For more detailed information, contact your area industrial hygienist.

2.2.3 Posting Designated Areas

Designated areas (e.g., an entire laboratory, an area of a laboratory, or a device such as a fume hood) shall be identified wherever *select carcinogens* are used or stored. Access control practices shall be commensurate with the hazard for these areas, and warning signs identifying the hazard shall be posted at entrances. These signs may include the LLNL health hazard communication poster (Appendix D, Fig. D-1) or one of the signs (e.g. #24) in Appendix D. If required exit procedures exist, they shall be posted at all exit points. The facility manager shall maintain a current list of the designated areas for the facility. This list should also be included in the FSP.

2.2.4 Inventory

The chemical names of all *select carcinogens* in an area, including those in storage, shall be listed on the health hazard inventory form (LL-5592) and forwarded to the MSDS coordinator (L-384). This inventory shall be updated annually.

2.2.5 Labeling, Packaging, and Storing

Danger labels (see examples in Appendix D) shall be placed on all primary and secondary (outer) containers with carcinogens whenever feasible. It is recommended that small containers (e.g., test tubes) be labeled; however, this is not required under the OSHA laboratory standard.

Carcinogens shall be packaged to withstand shocks, pressure changes, and any other conditions that may cause leakage of contents. These materials shall also be stored in designated areas, cabinets, or refrigerators within the primary work or storage area; and precautions shall be taken to protect them from rodents, weather, incompatible chemicals, and spillage. Additional storage requirements (e.g., use of double containers) may be necessary for certain highly potent carcinogens with physical properties that enhance spontaneous release and exposure (e.g., highly dispersible powders or volatile solids). For more information on packaging and storing these materials, consult with the area industrial hygienist.

For additional guidance on the proper methods for packaging and shipping carcinogenic materials, contact the Materials Management Section or refer to U.S. Department of Transportation regulations (49 CFR Parts 170–178).

2.2.6 Containment

The controls in this section are most reliable for protecting employees and the environment, and shall be applied to the fullest extent as the primary means of controlling exposure. Containment devices shall include a combination of the facility features and engineering controls below.

- Negative pressure of the workplace relative to common areas (e.g., corridors).
- Filters and traps on air, vacuum, and ventilation piping when technically feasible.
- Chemical fume hoods, glove boxes, closed systems, and other isolation devices.
- Nonpermeable work surfaces.
- Secondary containment trays.

The degree to which these controls shall be applied depends on the desired safety level of the operation. For example,

- Use of solid materials may not require a ventilated enclosure, but use of a gas may require a glove box.
- Operations involving volatile chemicals or those that generate aerosols shall be conducted in a ventilated enclosure or with an engineered close-capture exhaust system.
- Vertical laminar-flow hoods (e.g., biosafety cabinets) shall be evaluated and approved by the area industrial hygienist before they are used for carcinogen operations. These devices are rarely suitable because they recirculate or release exhaust air into the workplace.
- Analytical instruments that produce vapors or aerosols shall be connected to a mechanical exhaust system when used with carcinogens. "Ductless" hoods shall not be used for carcinogens.
- The exhaust discharge shall be located to prevent reentrainment into the building.
- Containment devices for carcinogens shall be designed to permit maintenance and decontamination activities with minimal exposure to carcinogens.

Animal-Exposure Facilities

- Animals used for experiments shall be housed in facilities in which potentially contaminated feed, feces, urine, exhaled breath, and bedding can be controlled.
- Personnel shall wear appropriate protective clothing whenever they enter these facilities, including respiratory protection for certain procedures for which local ventilation may not be feasible.

The following precautions shall be carefully assessed before specific safeguards are selected for animal experiments involving chemical carcinogens:

- Animal care and housing methods.
- Bulk chemical storage and disbursement procedures.
- Dosage preparation and challenge procedures.
- Waste management and disposal practices.
- Personal protection requirements.

Additional references for handling laboratory animals are provided in the section entitled "Reference" on p. 10.

For further information, contact the area industrial hygienist or the Director of Animal Facilities in the Biology and Biotechnology Research Program (ext. 2-5758).

2.2.7 Protective Equipment and Work Practices

Protective Equipment. Protective clothing shall be worn to safeguard regular clothing and the skin from contact with carcinogens. At minimum, such clothing shall include a fully fastened lab coat, safety glasses, and closed-toe shoes; lab coats shall only be worn within the confines of the laboratory. Additional clothing (e.g., disposable jumpsuits with head covers, face shields, respirators, shoe covers, and gloves) may be required for more stringent operations. NOTE: When selecting gloves, the carcinogen as well as the diluent, solvent, or other materials in use shall be considered because multiple layers may be necessary to prevent skin contact through permeation. Consult with the Industrial Hygiene Group for guidance on glove selection.

Contaminated clothing shall be removed and properly disposed of immediately.

Work Practices. Workers shall

- Not mouth pipette; use mechanical devices only.
- Wash hands immediately upon completing a procedure where a chemical carcinogen has been used and when leaving the laboratory. Immediately after skin contact or emergency exposure to a carcinogen, wash or, if appropriate, shower the affected area.
- Contact the Health Services Department (ext. 2-7459) for advice or medical evaluation, or both, after an exposure or potential exposure.
- Use hypodermic needles only if no other feasible substitution is available. Do not attempt to recap or cut used needles; dispose the entire needle and syringe in an appropriate sharps container for disposal as hazardous waste.

- Perform housekeeping, maintenance, and janitorial procedures (e.g., use wet cleaning and high-efficiency particulate air-filtered [HEPA] vacuums) to prevent aerosols from forming or contamination from spreading. Do not dry sweep carcinogen work areas. (Special clean-up procedures for spilled carcinogens shall be developed as part of the emergency plan.)
- Not eat, drink, smoke, chew gum or tobacco, apply cosmetics, or store utensils, food, or food containers in laboratory areas where chemical carcinogens are used or stored.

2.2.8 Monitoring

The hazard review may indicate the need for a workplace to be monitored for chemical exposure. Principal investigators are then responsible for contacting the area ES&H team to arrange for monitoring. This may focus on

- Personnel—to determine the potential for exposure or the need for medical consultation and / or surveillance.
- General area or process—to determine the effectiveness of engineering controls.
- Surfaces—to evaluate contamination control and the effectiveness of decontamination practices.
- Equipment and other supplies—before they are removed from the laboratory—to prevent the spread of carcinogens.

Carcinogens governed by OSHA-expanded standards (Table 2) shall be evaluated by the industrial hygienist to determine what personnel and workplace monitoring program is needed. If exposure levels for a substance routinely exceed the action level, monitoring shall continue periodically. An Ames bioassay test may be conducted to determine the extent of surface contamination and to verify if the work area is safe for normal use. Termination of any of the above monitoring routines shall be determined based on the exposure levels found.

If monitoring indicates an overexposure to a substance, the employee, supervisor, and Health Services Department shall be notified. Subcontractor employees shall be notified through the subcontracting company and the LLNL contract monitor.

2.2.9 Waste Disposal

Before beginning a laboratory activity that involves a chemical carcinogen, plans shall be developed for the handling and disposal of contaminated wastes and surplus carcinogens. Users shall properly segregate, package, and label all solid and liquid wastes contaminated with carcinogens. They shall also arrange for disposal with the area hazardous waste management technician. A copy of the hazard review form or the material safety data sheet (MSDS) shall accompany the waste being removed for disposal. Waste mixtures containing more than 0.1% of an OSHA select carcinogen shall be labeled as carcinogenic waste.

Table 2. OSHA carcinogens with expanded standards.

Chemical substance
2-Acetylaminofluorene
Acrylonitrile
4-Aminodiphenyl
Arsenic, inorganic
Asbestos[a]
Benzene
Benzidine
Bis(choromethyl) ether
Cadmium
1,2-Dibromo-3-chloropropane
3,3′-Dichlorobenzidine (and its salts)
4-Dimethylaminoazobenzene
4,4′-Methylene dianiline
Ethyleneimine
Ethylene oxide
Formaldehyde
Methyl chloromethyl ether
1-Naphthylamine
2-Naphthylamine
4-Nitrobiphenyl
N-nitrosodimethylamine
2-Propiolactone
Vinyl chloride

[a] Refer to Supplement 21.19 of this manual.

2.2.10 Decontamination

Recommended procedures for sanitizing equipment and surfaces contaminated with carcinogens shall be listed on the hazard review form and in the OSP or FSP. A decontamination process shall be carefully selected to ensure that all toxic or carcinogenic materials are destroyed or removed from the work surface.

2.2.11 Emergency Plan

Before beginning a laboratory activity that involves a chemical carcinogen, plans shall be developed for emergency response to spills, exposures, or accidents. These plans shall be included in the OSP or FSP and on the hazard review form. General guidance for emergency planning includes developing procedures for

- Evacuating the area and contacting the Fire Department.
- Restricting access to the area.
- Providing care to injured or exposed personnel.
- Showering or washing and obtaining medical attention immediately. A personal decontamination facility is available at the Health Services Department.
- Eliminating hazards that may still exist.
- Decontaminating the area.

2.3 Employee Training

Employees with potential for exposure to carcinogens shall receive sufficient information and training so that they can follow safe work practices and understand the relative significance of the potential hazards they may encounter. Supplement 21.01 of the LLNL *Health & Safety Manual* provides further details on employee education and training requirements.

Employees shall receive training in the following areas before beginning work with a chemical carcinogen:

- Methods (e.g., use of monitoring devices) and observations (e.g., visual appearance and odor) that may be used to detect the presence or release of a carcinogen.
- Physical and health hazards of the carcinogen.
- Permissible exposure limits (PELs) and threshold limit values (TLVs) established by the American Conference of Governmental Industrial Hygienists (ACGIH) for any OSHA-regulated substance used in the employee's assignment.
- Measures to protect them from hazards, including specific procedures implemented to control exposure (e.g., use of appropriate work practices, containment devices, personal protective equipment, and emergency procedures).
- Proper labeling, storage, and waste disposal practices.
- Relevant FSPs, OSPs, and hazard review forms.
- Job responsibilities.

This training can be accomplished through formal prepared courses and / or informal on-the-job training. A qualified instructor (e.g., a supervisor or a member of the area ES&H team) shall provide and document training in accordance with the LLNL *Training Program Manual*. Some of the training topics listed above may be on the MSDS and the hazard review form for special chemicals; these forms shall be made available to employees who use such substances.

Maintenance and custodial staff shall receive orientation and training (as appropriate) for their duties and potential exposure, as specified in the health hazard communication program in Supplement 7.02 of the LLNL *Health & Safety Manual*.

2.4 Medical Surveillance

The Industrial Hygiene Group or management shall inform the Health Services Department of employees with exposures to carcinogens that exceed OSHA or DOE action levels. (The ES&H team industrial hygienist monitors action levels and advises management which employees might be exposed.) Medical surveillance will be provided as defined by specific OSHA requirements. For workers who may have health concerns regarding their work, periodic physical examinations and consultations are available upon request.

3. Responsibilities

General responsibilities for all staff levels are described in Chapter 1 of the LLNL *Health & Safety Manual*. This section covers the job responsibilities for individuals who use chemical carcinogens in LLNL work areas.

3.1 Facility Manager

The facility manager shall

- Review completed hazard review forms.
- Know whether carcinogens are used, produced, stored, or handled in any way in the facility.
- Be familiar with this supplement and its content and objectives.
- Maintain a list of designated carcinogen workplaces.

3.2 Program Manager/Division Leader

The primary responsibilities of the program manager or division leader are to

- Identify and develop safety procedures, including OSPs, for each task involving carcinogens.
- Be familiar with this supplement and its applicability to his / her operations.
- Approve hazard review forms.
- Ensure that employees have applicable information and training before they are assigned to work with carcinogens.
- Determine which workers are required to participate in medical surveillance, and provide a list of these employees to the Health Services Department (L-723) before job assignment.

The program manager or the division leader may delegate these responsibilities to the project leader, the principal investigator, and / or the group leader.

3.3 Work Area Responsible Person

The person responsible for work areas in which carcinogens are used or stored shall

- Review
  - — Planned activities and hazardous chemicals being used.
  - — Emergency, waste disposal, and decontamination plans.
  - — Special personal protective equipment that may be required.
- Ensure that
  - — Employees in work areas know and follow the requirements for the carcinogen used, including the contents of FSPs, OSPs, and hazard review forms.
  - — Proper engineering and administrative controls are established and performed as intended.
  - — Personal protective equipment is available and functional.
  - — Assigned staff members have been trained in the hazards of the operation and that they adhere to appropriate protective measures.
- Identify carcinogens on purchase requisitions.
- Inventory all carcinogens in the work area, and send the inventory form to the Industrial Hygiene Group (L-384).
- Evaluate all carcinogenic operations using hazard review forms and have them approved by the Industrial Hygiene Group, the Environmental Protection Department, and the program manager / division leader.
- Initiate OSPs when required.

3.4 Employee

The employee shall

- Conduct each task in accordance with applicable FSPs, OSPs, and / or hazard review forms.
- Follow facility and institutional procedures.
- Attend required training.
- Participate in medical surveillance when required.
- Use protective equipment and devices as required.

3.5 Health Services Department

The Health Services Department shall

- Provide
  - — Medical surveillance for carcinogen workers in accordance with OSHA and DOE specifications.

  - — Decontamination support and medical consultation to workers involved in significant accidental exposures.
  - — Periodic physical examinations and consultations for concerned employees upon request.
- Maintain records for carcinogen workers, including copies of medical examination results and accident reports.

3.6 Industrial Hygiene

Industrial hygienists assigned to ES&H teams shall

- Assist with identifying
  - — Carcinogens and their categories (e.g., OSHA *regulated*, *select*, or *other*).
  - — Carcinogen workers.
- Approve hazard review forms for operations involving carcinogens.
- Determine the need for and frequency of workplace monitoring, and inform supervisors and employees of the results. The Health Services Department shall also be informed of measured or suspected overexposures.
- Provide specific training to programs or divisions, as requested.

3.7 Materials Management Section

The Materials Management Section shall

- Authorize the release of carcinogens in Stores only when an approved OSP or hazard review form accompanies the request.
- Receive carcinogen shipments and inspect packages for visible container damage and proper labeling.
- Provide guidance on the proper methods for packaging and shipping carcinogens off site.

3.8 Procurement Department

The Procurement Department shall send carcinogen purchase requisitions to the Industrial Hygiene Group of Hazards Control (L-384) for prior approval.

3.9 Supply and Distribution Department

The Supply and Distribution Department will release chemical carcinogens ordered through Central Supply only when the order has been approved by the Industrial Hygiene Group or the Materials Management Section.

3.10 Environmental Protection Department

In addition to approving the hazard review forms for operations involving carcinogens, the environmental analyst assigned to ES&H teams shall provide

- Guidance to carcinogen handlers on (1) how to implement environmental controls and procedures; and (2) the proper management of hazardous wastes that are contaminated with carcinogens to ensure compliance with all applicable federal, state, and local environmental requirements.
- Specific training to programs and divisions as required.

The hazardous waste management technician assigned to the ES&H team shall

- Provide specific guidance to carcinogen handlers (in accordance with HWM waste acceptance criteria) on how to properly segregate, package, and label solid and liquid wastes that are contaminated with carcinogens.
- Coordinate the disposal of waste generated in the area.

4. References

Industrial Hygiene Group, "List of LLNL-Designated Carcinogens," Hazards Control Department, Lawrence Livermore National Laboratory. Updated annually.

Lunn, G. and E. B. Sansone, *Destruction of Hazardous Chemicals in the Laboratory* (Wiley-Interscience, N.Y., 1990).

National Research Council, *Prudent Practices for Handling Hazardous Chemicals in Laboratories* (National Academy Press, Washington, D.C. , 1980).

R. Lewis, *Carcinogenically Active Chemicals: A Reference Guide* (Van Nostrand Reinhold, N.Y.,1991).

A. Furr, *Handbook of Laboratory Safety,* 3rd ed. (CRC Press, Boca Raton, Fla. 1990).

U.S. Department of Health and Human Services, National Institutes of Health (1978), *Guide for the Care and Use of Laboratory Animals*, DHEW Publication No. (NIH) 78–23.

DOE Order 5480.8A, "Contractor Occupational Medical Program," June 26, 1992.

DOE Order 5480.10, "Contractor Industrial Hygiene Program," June 26, 1985.

29 CFR 1910.1450, "Occupation exposure to hazardous chemicals in laboratories."

Environmental Protection Department, "Draft Guidelines for Design and Operation of Retention Tank Systems," February 1992 (UCRL-AR-103976).

Appendix A

Terms and Definitions

Action level	An airborne concentration of hazardous material that triggers implementation of health and safety controls such as workplace surveillance, monitoring, training, and medical examinations. The action level is often set at 50% of the OSHA permissible exposure limit.
Animal carcinogen	A material that shows sufficient evidence of causing cancer in animals; however, insufficient data are available to show a causal relationship to human cancer.
Carcinogen	Any substance that causes the development of cancerous growth in living tissue.
Close-capture system	A type of high-velocity exhaust ventilation system in which hazards or contaminants are controlled at their point of origin using ducts, funnels, cones, and flanges. The system may partially enclose the source of generation.
Designated area	An OSHA term for an area that may be used for working with s*elect carcinogens*, reproductive toxins, or substances that are quickly and highly toxic. Such area may be an entire laboratory, an area in a laboratory, or a device such as a hood or glove box. The term applies only to a "laboratory" (see definition below); for other workplaces, see "regulated area." (From 29 CFR 1910.1450.)
Human carcinogen	A material for which sufficient evidence of carcinogenicity from studies of humans indicates a causal relationship between the agent and human cancer.
Human-suspect carcinogen	A material with limited evidence of carcinogenicity in humans and generally substantiated evidence as an animal carcinogen.
Laboratory	A facility where relatively small quantities of hazardous chemicals are used on a nonproduction basis, operations are designed to be easily and safely performed by one person, multiple chemical procedures are done, and protective practices and equipment are available and in common practice. (From 29 CFR 1910.1450.)
Mutagen	A material that can alter genetic information within cells.
Medical surveillance	A regulatory or institutionally prescribed examination protocol for specified occupational hazards.
OSHA-expanded standard	A regulation that specifies detailed requirements for workplace controls, employee training, and medical examinations.
Other carcinogen	A carcinogenic material that does not meet the definitions of *select* or *regulated carcinogen*.

Permissible exposure limit (PELs)	The OSHA permissible exposure limit for an airborne concentration of a hazardous chemical in the workplace. Permissible exposure limits are listed in 29 CFR 1910, Subpart Z.
Regulated area	An OSHA term for a workplace with specified engineering and work-practice controls and where entry and exit are restricted and controlled.
Regulated carcinogen	For the purpose of this policy: in nonlaboratory workplaces, a material that is specifically regulated by an OSHA standard or a DOE order. Usage restrictions and controls are more stringent for these carcinogens than for others. See also *select carcinogen* and *other carcinogen*.
Select carcinogen	An OSHA term for a substance that is used in a laboratory and meets one of the following criteria: • Regulated by OSHA as a carcinogen. • Listed under the category "known to be carcinogens'' in the *Annual Report on Carcinogens* by the National Toxicology Program (NTP). • Listed in Group 1 (carcinogenic to humans) in the International Agency for Research on Cancer (IARC) *Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man*. • Listed in either Group 2A or B by IARC or is under the category "reasonably anticipated to be carcinogens" by the NTP and causes statistically significant tumor incidence in experimental animals according to the following criteria: — After inhalation exposure of 6 to 7 hours per day, 5 days per week for a significant portion of a lifetime, to dosages of less than 10 mg/m^3. — After repeated skin application of less than 300 mg/kg of body weight per week. — After oral dosages of less than 50 mg/kg of body weight per day. (From 29 CFR 1910.1450.)
Teratogen	A material that can cause fetal abnormalities.
Threshold limit values (TLVs)	Time-weighted average concentrations of materials for a normal eight-hour workday to which nearly all workers may be repeatedly exposed without adverse effect. These values are developed and published by the ACGIH.
Tumor $dose_{50}$ (TD_{50})	The amount of a substance that will result in tumor formation in 50% of a test population of exposed experimental animals.

Reference

National Toxicology Program, *Annual Report on Carcinogens,* U.S. Department of Health and Human Services, Research Triangle Park, N.C. (latest edition).

International Agency for Research on Cancer, *Monographs on the Evaluation of Carcinogenic Risk of Chemicals to Man,* World Health Organization, Lyon, France (latest edition).

Appendix B

Safety Control Level Assignments

The hazard review form shall indicate the safety control level for the particular operation being assessed. These levels consist of groups of controls that provide increasing degrees of protection to reduce exposure to and release of hazardous agents. The general elements of a safety control level shall be considered as an initial planning guide when establishing a workplace for carcinogens; fewer or additional controls may be warranted based on the operational analysis performed by the experimenter or supervisor, the area team industrial hygienist, and the environmental analyst. An overall safety control level shall indicate the extent of risk and the degree of control required to reduce exposure. The criteria and methods used to evaluate carcinogen operations are described below.

B.1 Relative Hazard Factors

The relative hazard of an operation is determined by evaluating the carcinogen, its potency and physical characteristics, and the route of and potential for exposure (including duration).

B.2 Calculating an Overall Hazard Score

The following formula gives an overall score of the potential hazard used to assign a safety control level. Points are assigned to each factor using the data in Tables B-1 through B-6, which are at the end of this appendix.

Hazard Score = $T \times P \times C \times R \times E$, where

T = Type.
P = Potency.
C = Physical characteristics.
R = Route of exposure.
E = Exposure potential.

B.3 Safety Control Level Needs

Safety control level needs for each operation involving carcinogens are based on the score obtained in the section entitled "Calculating an Overall Hazard Score." See the section entitled "Safety Control Level Features" below for the recommended safety control level for each operation. *Note that these factors and calculations are not intended to be precise; use professional judgment where necessary.* OSHA-regulated carcinogens may require additional safety features for compliance.

B.4 Safety Control Level Features

Each operation, rather than each substance, shall be evaluated and assigned controls as needed. Below are the controls for each level (see also Table 7 at the end of this appendix). For laser dyes, see also Chapter 28, Appendices A and B, of the LLNL *Health & Safety Manual*.

B.4.1 Low Safety Control Level

The low safety control level is appropriate for work involving chemicals that have a low-hazard potential and for work that does not require special engineering design features or containment equipment. Public

access is allowed for areas designated as a low safety control level. The requirements for this level, which are generally those of good work practice, are described below.

Access

- Close doors when operations are in progress.
- Allow only those animals involved in the experiment in the facility.
- Advise maintenance and emergency personnel of the potential hazards and the proper precautions.

Facilities

- Provide
  - — Hand wash, eye wash, and safety shower facilities.
  - — Workers with access to a change room and shower facility.
  - — Minimum general ventilation of 15 cfm per person.
  - — Pest control program.
- Design surfaces for easy cleanup and decontamination.

Work Practices

- May do most work on an open bench.
- Maintain cleanliness of work surfaces; clean up after each task and spill.
- Do not mouth pipette; use mechanical devices only.
- Do not eat, drink, smoke, chew gum or tobacco, store food, or apply cosmetics in the work or storage areas.
- Use
  - — Eye protection.
  - — Protective clothing and other personal protective equipment as needed, including appropriate gloves and respirators.
  - — Hypodermic needles only if no other feasible substitution is available. Do not recap or cut used needles; dispose of the entire needle and syringe in an appropriate sharps container.
  - — Only the amount of material needed to complete the project.
  - — Carcinogen warning labels on all containers.
- Post appropriate warning signs at entrances while carcinogen operations are in progress.
- Keep only a minimum amount of the material for use and in storage. Consolidate and control storage areas.
- Follow proper waste-handling and disposal procedures for chemicals and contaminated clothing. Do not send contaminated clothing through the laundry service.
- Wash hands after each task and before leaving the work area.
- Dispose of *all* excess chemicals and unusable equipment properly when the project is completed.
- Sanitize contaminated areas with the appropriate agents.
- Maintain and periodically inspect liquid-waste retention systems in accordance with guidelines for the Environmental Protection Department (see reference in Section 4).
- Obtain proper janitorial and maintenance practices and procedures.

B.4.2 Medium Safety Control Level

The medium safety control level is appropriate for work with chemicals that have a moderate-hazard potential and require some engineering design features. Note that chemical fume hoods or ventilated enclosures are required for containing operations that produce significant amounts of airborne gas, vapor, or particulates. It is not necessary to isolate the workroom from the general traffic pattern of the building for this safety control level; however, public access is not permitted while operations are in progress.

All of the requirements for the low safety control level apply to this level, including the following:

Facilities

- Maintain proper ventilation systems such that the pressure in workrooms is always negative relative to access corridors.
- Do not recirculate exhaust air from primary containment equipment.
- Protect house vacuum lines with appropriate filters and liquid traps.

Work Practices—Do not work on an open bench; conduct all work within chemical fume hoods or within other equivalent containment equipment.

B.4.3 High Safety Control Level

The high safety control level is appropriate for work with chemicals that have a high-hazard potential and require special engineering design features and contamination equipment. All requirements for the low and medium safety control levels apply to this level, including the following:

Access

- Prohibit public access.
- Control employee access.
- Close doors at all times.
- Isolate work area from the general traffic pattern of the building.
- Maintain a written record of all persons entering and using the area.

Facilities

- Ensure that all walls, floors, and ceilings are sealed.
- Filter or clean exhaust air before it is released into the environment.

Work Practices

- Conduct all work in glove boxes or comparable isolated containment.
- Store carcinogens in primary or secondary containers to avoid personnel exposure in case of accidental container breakage.
- Use protective clothing while handling carcinogens. At minimum, protective clothing shall consist of a fully fastened disposable lab coat or coveralls, safety glasses, and closed-toe shoes. Wear disposable lab coats (LLNL Stock Nos. 8405-63672 and -63673) whenever possible.
- Remove protective clothing and equipment, and wash hands before leaving the facility; showering may be required for some operations.

Table B-1. Factor T—Carcinogen types.

Carcinogen types	Points
Proven human carcinogens	**10**
Suspected human carcinogens	**9**
Animal carcinogens; human potential	**6**
Suspected animal carcinogens; possible human potential	**5**
No data	**1**
Negative data	**0**

Table B-2. Factor P—Carcinogenic potency using (a) TD_{50} and (b) TLV/PEL.

(a)

Carcinogen potency (TD_{50})		Points
<100	**ng**	**10**
0.1–1	**μg**	**9**
1–10	**μg**	**8**
10–100	**μg**	**7**
0.1–1	**mg**	**6**
1–10	**mg**	**5**
10–100	**mg**	**4**
0.1-1	**g**	**3**
1–10	**g**	**2**
>10	**g**	**1**

(b)

Carcinogen potency (TLV/PEL) (ppm or mg/m^3)	Points
0.001	**10**
0.01	**9**
0.1	**8**
1.0	**7**
10	**6**
100	**5**
1000	**4**
>1000	**3**

Table B-3. Factor C—Physical characteristics of contaminants.

Physical characteristics	Points
Present in a vapor or a gaseous phase at standard temperature and pressure (STP; temperature = 25°C; pressure = 750 mm Hg)	10
Present as a respirable dust or aerosol at STP*	9
Present as a volatile liquid at STP	7
Present as a volatile solid at STP	6
Present in a mixture with a volatile solvent	5
Nonvolatile liquid at STP	4
Nonvolatile solid at STP (dust)*	3
Nonvolatile solid at STP (granular)	2
Nonvolatile solid at STP (blocks)	1

When considering Factor C, the following shall be contemplated:

- **Physical state at room temperature (e.g., solid, liquid, or gas); if solid, is particle size respirable?**
- **Vapor pressure (V.P. at 20°C in mm Hg) —is airborne concentration approaching action level or PEL?**
- **Evaporation rate (ether = 1).**
- **% Volatile by volume %.**
- **Melting point (M.P.).**
- **Boiling point (B.P.).**
- **Water solubility.**
- **Lipid solubility—promotes skin absorption.**
- **Specific gravity; settling rate.**
- **Other relevant information.**

***Assumes a dust is respirable until proven otherwise.**

Table B-4. Factor R—Route of exposure.

Route of exposure	Points
Inhalation, ingestion, and skin contact	10
Inhalation and skin contact	8
Inhalation and ingestion	7
Skin contact and ingestion	6
Inhalation only	6
Skin contact only	4
Ingestion only	3

Table B-5. Factor E—Exposure potential.

Exposure potential	Points
High-exposure potential	10
Intermediate-exposure potential	5
Low-exposure potential	1
Very low exposure potential	0.1

The following shall be considered for arriving at Factor E:

- **Quantity and physical state of material.**
- **Frequencies and duration (hrs/week) of exposure.**
- **Work processes (e.g., heating, grinding, or aerosol generating).**
- **Presence of promoters of respirable aerosols.**
- **Training of operator/experimenter.**
- **Work practices (e.g., wet handling of asbestos).**
- **Other relevant information.**

Table B-6. Safety control level requirements.

Points calculated	Level required
0 to 10^2	Low
$l0^2$ to 10^4	Medium
$>10^4$	High

Table B-7. Safety control level recommendations for use of chemical carcinogens.

Safety control level		Low	Medium	High
1.0	Access			
1.1	General	Post signs in area; close door while working.	Post signs in area; close door while working.	Post signs in area; close door at all times; isolate from building traffic.
1.2	Public	Limit to only those involved.	Limit to only those involved.	Prohibit entry.
1.3	Employees	Limit to only those involved.	Limit only to those involved.	Control; maintain written log.
1.4	Animal	Permit only those in experiment.	Permit only those in experiment.	Permit only those in experiment.
1.5	Maintenance and emergency personnel	Advise of hazards and precautions.	Advise of hazards and precautions.	Advise of hazards, precautions, and entry/exit procedures.
2.0	Facilities			
2.1	Handwash, eyewash, and safety shower	Required.	Required.	Required.
2.2	Change room and shower	Provide access.	Provide access.	Provide access.
2.3	Ventilation, general	Provide at least 15 cfm/person; do not recirculate.	Provide at least 15 cfm/person; negative pressure in work area; do not recirculate.	Provide at least 15 cfm/person; negative pressure in work area; do not recirculate; filter exhaust air.
2.4	House vacuum	Use of filter and trap is optional.	Use filter and trap.	Use filter and trap.
2.5	Work surfaces	Design for easy cleaning and decontamination.	Design for easy cleaning and decontamination.	Design for easy cleaning and decontamination; ensure that all walls, floors, and ceilings are sealed.
2.6	Pest control	Required.	Required.	Required.

Table B-7, Continued.

Safety control level		Low	Medium	High
3.0	**Work practices**			
3.1	**Open bench**	**Permitted.**	**Prohibited.**	**Prohibited.**
3.2	**Ventilated containment**	**Recommended.**	**Use hood or equivalent.**	**Use glove box or equivalent.**
3.3	**Work surface and floor cleaning**	**Use wet method or HEPA vacuum; decontaminate.**	**Use wet method or HEPA vacuum; decontaminate.**	**Use wet method or HEPA vacuum; decontaminate.**
3.4	**Mouth pipetting**	**Prohibited.**	**Prohibited.**	**Prohibited.**
3.5	**Syringes**	**Use only if no other substitute is available.**	**Use only if no other substitute is available.**	**Use only if no other substitute is available.**
3.6	**Storage and labeling**	**Control and keep minimal amount; eliminate excess; label containers and cabinets.**	**Control and keep minimal amount; eliminate excess; label containers and cabinets.**	**Control and keep minimal amount; eliminate excess; label containers and cabinets; use secondary containment.**
4.0	**Personal protective equipment and hygiene**			
4.1	**Eye protection**	**Required.**	**Required.**	**Required.**
4.2	**Body protection**	**Use lab or shop coat; change clothes before leaving.**	**Use lab or shop coat; change clothes before leaving.**	**Use disposable garments; change clothes before leaving.**
4.3	**Food, beverages, or cosmetics**	**Prohibit use or storage.**	**Prohibit use or storage.**	**Prohibit use or storage.**
4.4	**Handwashing**	**Wash after each task and before leaving.**	**Wash after each task and before leaving.**	**Wash after each task and before leaving; showering may be required.**
4.5	**Gloves**	**Recommended.**	**Recommended.**	**Recommended.**

Table B-7, Continued.

Safety control level	Low	Medium	High
5.0 Waste			
5.1 Retention tanks	**Inspect regularly.**	**Inspect regularly.**	**Inspect regularly.**
5.2 Contaminated garments	**Do not launder.**	**Do not launder.**	**Do not launder.**
5.3 Chemicals and equipment	**Prepare a waste plan; segregate and label waste containers.**	**Prepare a waste plan; segregate and label waste containers.**	**Prepare a waste plan; segregate and label waste containers.**

Appendix C

Hazard Review Form

The hazard review form (Fig. C-1) or its equivalent shall be used to evaluate all work in laboratories involving *select carcinogens* and work in other areas involving *regulated carcinogens*. It may also be used for *other carcinogens*. When combined with a building's controls for using carcinogens, this form may eliminate the need for OSPs.

NOTE: Instructions for completing the form are on the reverse side. The principal investigator / supervisor, environmental analyst, and the industrial hygienist for the area ES&H team shall complete the hazard review form together. The program manager (or equivalent), environmental analyst, and the industrial hygienist shall approve the form. Each party shall retain a copy on file. The facility manager shall review the form for informational purposes (he / she may not necessarily be an approver).

Form Number: Bldg._____.___

HAZARD REVIEW

INFORMATION—SECTION I Date:_____ Start Date: _____

Bldg.:_____ Rm.: _____OSP / FSP #: _____ ES&H Team: _____

Prepared by:_____ Phone:_____

Principal Investigator / Supervisor: _____ Phone: _____

Other Personnel Involved: _____

Chemical Name: _____ CAS #: _____ By-Products: _____

Highest Concentration: _____ Total Quantity: _____

PROCESS DESCRIPTION—SECTION II Describe methods: _____

_____

_____

Duration / Frequency:_____

Route of Exposure: Contact by: _____ Eye _____ Skin

_____ Inhalation_____ Ingestion_____ Other

HAZARD INFORMATION—SECTION III MSDS on file? _____ Yes _____ No _____ Unavailable

Type of Carcinogen: _____ Human _____ Animal _____ Potential

Emergency Response Procedures

Fire Response: _____

_____

Spill Response:_____

_____

_____

Decontamination: _____

_____

Accidental Injury / Exposure—CONTACT MEDICAL AND DO THE FOLLOWING:

_____

HAZARD CONTROL REQUIREMENTS—SECTION IV (To be completed by ES&H team industrial hygienist)

TWA _____ STEL _____ CEILING_____ Standard _____

Safety Control Level _____ (see Supplement 21.16 of the LLNL *Health & Safety Manual*)

Monitoring	_____Yes _____ No	Ventilation	_____Yes _____ No
Medical Surveillance	_____Yes _____ No	Regulated / Designated Area	_____Yes _____ No
Recordkeeping	_____Yes _____ No	Personal Protective Equipment	_____Yes _____ No
Signs	_____Yes _____ No	OSP	_____Yes _____ No
Training	_____Yes _____ No		

ENVIRONMENTAL REQUIREMENTS—SECTION V (To be completed by the ES&H environmental analyst.)

Permit required? _____ Yes _____ No

Referred to: _____ Date: _____

(Name)

NEPA required? _____ Yes _____ No

Referred to: _____ Date _____

(Name)

Hazardous waste generated? _____ Yes _____ No

Waste disposition: _____ HWM _____ Other

(describe)

Comments:

Distribution: Principal investigator / supervisor, ES&H team FSP file, team environmental analyst, team industrial hygienist, program manager, and facility manager.

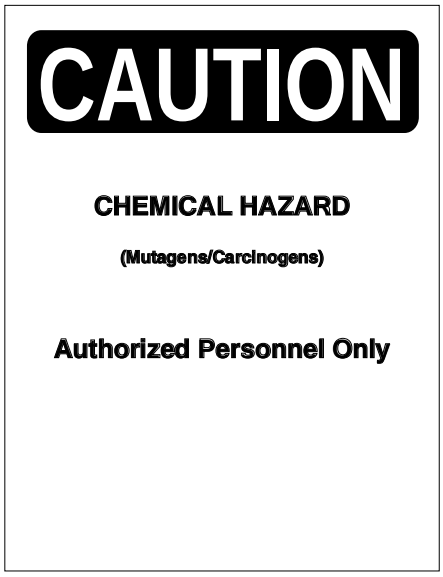
Figure C-1. Hazard review form.

Figure C-1. Hazard review form (Continued).

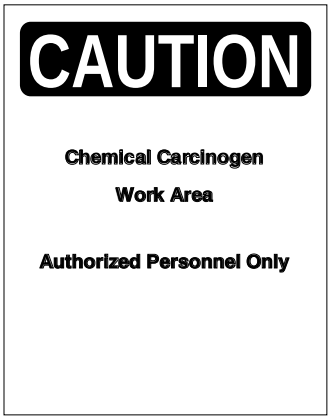
Appendix D

Warning Signs and Danger Labels

The signs and labels in this appendix are available from Central Supply or the Industrial Hygiene Group of Hazard Control (ext. 2-1214). Custom signs can be made for unique circumstances; however, there are established standards for lettering size, color, and wording. Consult with your area ES&H team industrial hygienist for specific details. Note that these standards are particularly important when developing signs for OSHA carcinogens and established regulated areas.



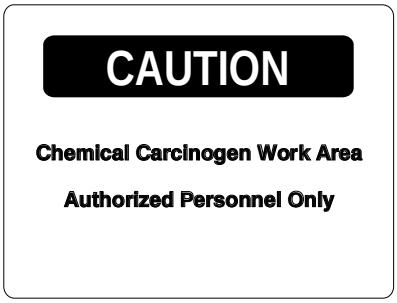
(Industrial Hygiene Group Sign #23; 8 1/2 × ll in.)



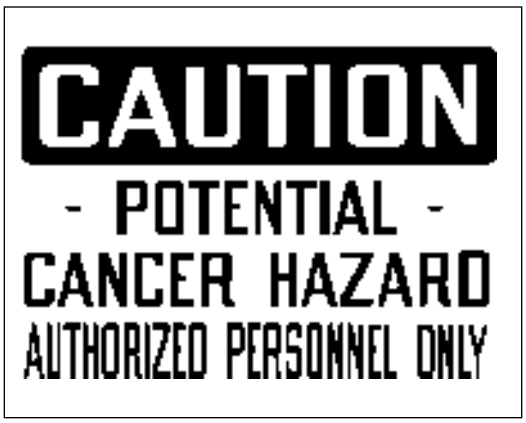
(Industrial Hygiene Group Sign #24; 8 1/2 × ll in.)

(Industrial Hygiene Group Sign #27; 4 1/2 × 6 1/2 in.)

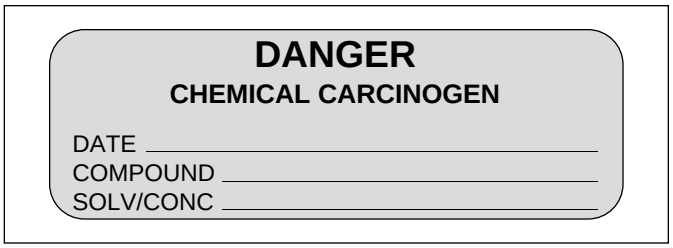
(Industrial Hygiene Group Sign #28; 4 1/2 × 6 1/2 in.)



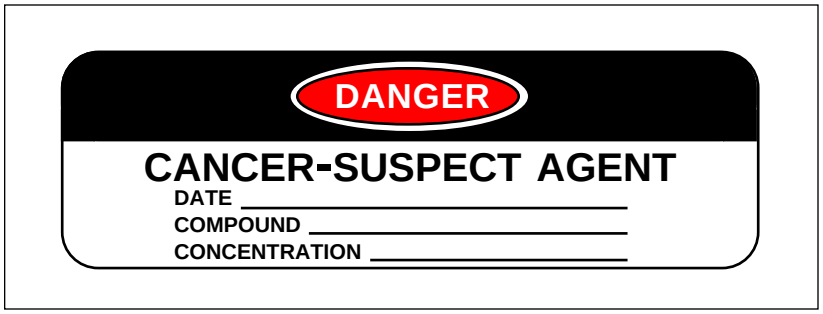
(Industrial Hygiene Group Sign #29;
4 1/2 × 6 1/2 in.)



LLNL Stock No. 4280-57346 (10 × 14 in.)



LLNL Stock No. 4280-64462 (1 × 3 in.)



LLNL Stock No. 4280-67347 (1 × 3 in.)

Health Hazard Communication

Lawrence Livermore National Laboratory

HAZARDS WARNING

CHEMICAL		BIOHAZARD		PHYSICAL	
[ ]	Flammables	[ ]	Human Fluids	[ ]	Ionizing Radiation
[ ]	Corrosives (acids, bases)	[ ]	_____	[ ]	RF/MW Radiation
[ ]	Explosives			[ ]	Lasers
[ ]	Reactives (oxidizers, water reactive, light sensitive, peroxide formers, pyrophoric)			[ ]	Strong Magnetic Fields
				[ ]	High Voltage
[ ]	Particularly Hazardous Substances (carcinogens, reproductive toxins, acutely toxic substances)			[ ]	High Pressure
				[ ]	High Noise
[ ]	Laboratory Use of Chemicals (H&S Manual Supplement 21.01)			[ ]	_____

SPECIAL HAZARDS

Additional guidance for hazardous operations in this area is provided in the following safety procedures:

FSP/OSP Number	Location of Controlled Copy	Responsible Individual
_____	_____	_____

Material Safety Data Sheets (MSDS) for hazardous materials in this area are available in Building _____ Room _____ and through the MSDS Hotline at ext. 3-2122.

Books and information on hazards identification, the safe handling of hazardous materials, the Laboratory's Chemical Hygiene Plan and the Health Hazard Communication Program may be found in Building _____ Room _____ .

Additional Information may be obtained from other responsible personnel:

Responsible Person:	Phone:
Program Supervisor:	Phone:
Facility Manager:	Phone:
ES&H Team Leader:	Phone:
Health & Safety Tech:	Phone:
Hazardous Waste Tech:	Phone:

Approved by _____ Date _____

Figure D-1. Example of a typical LLNL health hazard communication poster (in revision).